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FORMAL REPORT 3-53

COLD WATER PROTECTION [illegible] CONDITIONS

CONDUCTED

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LCDR., [illegible]

NAVY EXPERIMENTAL DIVING UNIT

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WASHINGTON NAVY YARD
WASHINGTON, D.C. 20390

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COLD WATER PROTECTION UNDER FIELD CONDITIONS

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13. ABSTRACT

Eleven runs were made for this evaluyation, all with the subjects immersed byt not submerged in 36°F water. Four runs were made under resting conditions, and four under swimming conditions, to test various types of insulating underclothing worn beneath the standard swim suit. In addition, three dives were made under swimming conditions to test three types of insulating swim suits.

The four underclothing materials were: 1/8" flat ensolyte, 1/4" flat ensolyte, 1/4" button ensolyte, and one suit of 100% wool underwear. The three swim suit materials were: 1/4" flat ensolyte, 1/4" flat chemically blown neoprene, and 1/4" flat mechanically blown latex.

The 1/4" flat ensolyte proved to be the best insulator for use as underclothing, but its buoyancy probably makes it unsuitable for underwater swimming; it may be satisfactory for deep sea divers. The 1/4" flat ensolyte swim suit may provide satisfactory insulation of the underwater swimmer if its depth characteristics are all right.

Further evaluations should be made, covering both diving and swimming under field conditions.

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FORWARD

At the direction of the Bureau of Ships, the Experimental Diving Unit last year developed and tested insulating suits from several materials furnished by the Bureau. The results appear in EDU Report 5-52.

In order to evaluate these materials, together with some newly developed ones, under conditions more like those found in actual underwater demolition and diving operations in cold water, the Bureau directed that tests be conducted in arctic waters during the summer of 1953. An Experimental Diving Unit representative accompanied the arctic re-supply expedition to northern Greenland during July and August, and tests were made in these waters. The tests were made in North Star Bay, Thule, Greenland. They were necessarily limited to observation of the insulating and buoyancy qualities of the suits under surface swimming conditions. Diving operations were not carried out because of the lack of facilities, but the inf rmation gained from the swimming tests can be suitably applied to diving conditions.

Although conducted in the field without benefit of laboratory controlled conditions, and of necessity limited to subjective determinations, the arctic water tests were valuable from the practical standpoint by indicating generally those materials which show the greatest promise for further development.

ABSTRACT

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CONTENTS

I. OBJECT

The primary object of this study is to devlop a type of protective clothing which will be suitable in insulation and buoyancy qualities for use by the underwater swimmer in cold water.

A secondary object is to consider the materials developed for possible use as underwear by deep sea divers under conditons of extreme cold.

II. DESCRIPTION

A. Two general types of clothing were tested.

1. Underclothing

This clothing is intended to be worn under the standard swim suit, and consists of the following separate pieces.

a. Hood, covering entire head except face.

b. Jacket, waist length, with tie strings for closing up front.

c. Three-finger mittens, thumb and forefinger separate, tight rubber cuffs.

d. Trousers, waist to ankle, tie string closing waist.

e. Boots, covering foot and ankle.

2. Swim suits

These were one-piece suits covering all but the swimmer's face and hands. Separate mittens of the same material were slipped on over the hands and a watertight seal was effected with the sleeve cuff of the suit. Back closure of the suit was made by means of a watertight zipper.

B. Materials

1. Underclothing

All the underclothing was made of ensolyte, a type of expanded polyvinylchloride (unicellular synthetic foam rubber). Three forms of this material were tested.

a. Flat ensolyte, 1/8" thick.

b. Flat ensolyte, 1/4" thick.

c. Button ensolyte, 1/4" thick with 1/4" high buttons.

d. In addition, a one-suit thickness of 100% wool diving underwear was tested.

2. Swim suits

Each of the three swim suits was made of 1/4" thickness of the following new materials.

a. Ensolyte.

b. Chemically blown neoprene.

c. Mechanically blown latex with a thin latex skin.

C. Subjects

Five subjects were used for the test. Two of these were experienced swimmers from UDT 4, one was the BuShips representative from EDU and the other two were volunteers from the military department of USNS Greely.

III. PROCEDURE

A. Underclothing

The first tests were made using the four types of underclothing described above. The subject dressed in the trousers, jacket, boots, and gloves, wearing the material directly against the skin. He then pulled a standard swim suit over the underclothing and put swim fins on his feet.

1. Rest runs

After dressing, the subject entered the water and, after checking for leakage through the swim suit, remained at rest until he became uncomfortably cold. The run was terminated then and the subject reported upon fit of the clothing, buoyancy, leakage, insulating quality, etc.

2. Swim runs.

Following the rest runs, a series of runs using the same four types of underclothing under swimming conditions was made. Swimming conditions were considered to be in effect when the subject remained continually in motion and expended the amount of effort he would require to maintain a speed near 0.8 knot. On account of the extreme buoyancy and bulkiness of the clothing worn, this criterion was at best only a rough approximation. However, for the short time and the limited number of personnel available, it was the only feasible arrangement possible under the field conditions experienced.

3. Other runs

Runs combining swimming and resting conditions were eliminated because of the time and personnel limitations and because there was obviously very little difference between the combination runs as originally planned and the swim runs as actually carried out.

Originally it was planned to make runs under diving conditions, but field conditions were also inadequate for satisfactory duplication of diving conditions. In particular, underwater breathing apparatus was entirely lacking.

B. Swim suits

Upon receipt of the swim suits made up of the three new materials, tests were run with the subject dressed in the suit alone, without underwear. The tests were made under swimming conditions, and only one run was made with each suit, because various obvious faults in two of the three suits rendered further testing valueless.

C. Data

The data gathered were generally qualitative rather than quantitative and subjective rather than objective. These conditions were imposed by the impossibility of providing laboratory instrumentation in the field. The following measurements and observations were made.

1. Body temperature before and after the run.
2. Water temperature.
3. Air temperature.
4. Run durations.
5. Amount of leakage.
6. Insulating quality.
7. Relative buoyancy.
8. Bulk of clothing on the subject.
9. Subjective sensations.

Although subjective feelings of the men were the primary observations made, they are considered adequately conclusive of the value of each type of material tested.

IV. RESULTS

Tabulation of the important data from the tests appears in Table I.

Body temperature is not shown, having been determined to be of minor importance in measuring the swimmer's comfort. Air temperature is not shown since it had no effect upon the subject in the water.

The following specific results are pertinent.

1. Underclothing.

Of the four types of materials tested as underclothing for a standard swim suit, the 1/4" flat ensolyte gave the best results. This material proved comfortably warm to all subjects in 36° water although leakage of a quart or more occurred. The longest run in this material was only 90 minutes; however it was not terminated by lack of insulating properties, and the observer is convinced that runs up to three hours are quite feasible.

The 1/8" flat ensolyte underclothing had only fair insulating properties. The 1/4" button ensolyte underclothing was even more bulky and buoyant than the 1/4" flat ensolyte.

The extreme buoyancy of all three materials prevents true swimming when they are worn beneath the standard swim suit. Even the addition of 20 pounds of weight at the belt was insufficient to overcome the buoyancy. Further addition of enough weight to neutralize the buoyant effect would have created enough bulk to prevent the subject from swimming.

2. Swim suits

Of the three types of materials tested as swim suits, the 1/4" flat ensolyte gave the best results. It was quite flexible, an excellent insulator, and when worn alone in the form of a swim suit was, suprisingly enough, not too buoyant to prevent swimming. Leakage was not particularly detrimental because the material did not absorb it and the body heat remained within the suit. It is felt that an open-circuit air-demand SCUBA would give the swimmer neutral buoyancy.

TYPE OF SUIT	NUMBER OF DIVERS	REMARKS
1. Pirelli	4	Leak via seal stopped all dives; may be slight leakage via face plate.
2. Standard Swim Suit (double zipper)	24	All but two dives leakes; main leaks c zipper tops and ches flutter valve.
3. Standard Swim Suit (clamp back type)	10	Leaked via chest flutter vaive; leaks stopped when this valve was closed off.
4. U.S. Diver's	1	Suit tore too readily; came apart at seams to readily.

TABLE #1

Number of Dives	Underwear				Polyvinyl chloride															Numbers of Dives
	100% wool	100% cotton	Nylon	cotton wool Comb	½" Suit	¼" suit	⅞" Suit	½" Suit	⅛" mitts	¼" mitts	⅜" boots	¼" socks	100% wool socks	100% wool gloves	100% wool water proof	Surg. rubber gloves	Rock. wool gloves	Gloves Worn To Suit		
4	3 sets												3 pairs	✓				✓		1, 2, 3, 4
1	3 sets										✓		1 pair	✓				✓		5
1					✓						✓		"	✓				✓		6
1	1 set										✓		"	✓		✓		✓		7
1	2 sets										✓		"	✓		✓	✓			8
8	2 sets								✓		✓		"	✓						9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
4	2 sets								✓		✓		"	✓		✓				10, 11, 12, 13
2					✓				✓			✓	"		✓					21, 22
1	1 set					✓				✓		✓	"		✓					24
1	1 set				✓					✓		✓	"							25
3	1 set	✓								✓		✓	"		✓					24, 23, 23
1	2 sets	✓								✓		✓	"		✓					26
1				2 sets					✓		✓		"		✓					27
1	1 set			1 set						✓		✓	"		✓					30
2	1 set			1 set						✓		✓	"		✓					31, 32
1	2 sets									✓		✓	"		✓					33
8		✓			✓					✓		✓	2 pairs		✓					34, 35, 36, 37, 38, 39, 40, 41
12								✓		✓		✓	"	✓	✓					42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55
2							✓			✓		✓	"	✓	✓					56, 57

Number of Dive	Water Temp. (of)	Type of Suit	Condition of Underwear	Total Duration of Dive (minutes)	Reason for Terminating Dive
1	48	Standard (Clamp)	Dry	60	Diver still warm, dry able
2	48	U.S. Divers	Wet	29	Uncomfortably cold;num numb, wet hands, feet.
3	45	Standard (zipper)	Wet	72	Hand, feet became uncomfortably cold, numb wet after first 54 mir
4	45	"	Wet	103	Hands remained dry;fe feet became wet,cold, numb after first 40 mi
5	45	"	Wet	65	Physical discomfort c face mask.
6	45.5	"	Wet	58	Uncomfort.cold,wet, numb hands,one foot.
7	45	"	Wet	72	Physical discomfort face mask
8	44	"	Wet	30	Physical discomfort c face mask
9	44	"	Dry	20	Uncomfort, cold, wet numb hands and body
10	47	"	Wet	37	Uncomfort. cold, wet numb hands.
11	45	"	Wet	30	Uncomfort. cold, wet numb hands.
12	46	"	Wet	22	Uncomfort. cold, wet, numb left hands.
*13	44	"	Wet	321/2	Uncomfort. cold, wet numb hands.
14	46	"	Wet	20	Uncomfort. cold, wet, numb hands.
15	46	"	Wet	65	Uncomfort. cold, wet. numb left hand.
*16	45	Two-Piece Rubber	Wet	311/2	Uncomfort. cold, wet, numb hands and ears.
*17	47.5	"	Wet	63	Uncomfort. cold, wet numb hands.
18	43	"	Wet	60	Uncomfort. cold, wet, numb hands.
19	40	"	Wet	55	Uncomfort. cold, wet waist, thighs, crotch
*20	36	"	Wet	40' 30'	Uncomfort. cold, wet, numb hands. Hands still comfort. after first 40 min. Uncomfort. cold, wet, numb hands

TABLE #3A